2. SAMPLING

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Page

2. SAMPLING

2.1 OVERVIEW

The purpose of environmental sampling and analysis is to obtain data that describe a particular site at a specific point in time from which an evaluation can be made as a basis for possible action. In this process, the collection of valid samples is the vital first step. Sampling should be done with the same care as the analysis, and both should be done with a rigor that is appropriate for the project at hand. In order for the data to be meaningful, sampling must be carried out with a clear purpose and with an understanding of the problem to be solved and the physical conditions that exist.

At EML, environmental sampling is carried out for purposes such as inventorying a pollutant at a specific point in time, calculating the pollutant transfer coefficients, and reconstructing deposition chronologies. Through these long-term studies, experience has been gained in sampling radioactive fallout, air particulates and gases, and total and rate of deposition. In this section, we describe procedures developed by EML for environmental sampling, that are currently not used at EML but are still valid and are used at other laboratories.

General guidance on collecting valid samples is given in Section 1.6.2, Volume I. Unlike chemical or radiometric analyses, it is not possible to set down step-by-step procedures for sampling. For example, a variety of samples may be required for the purpose of establishing relationships between concentrations in different matrices to further the understanding of dynamic processes. Also, the concentration of a particular pollutant in an environmental matrix will change with time and location.

Usually, the crucial decisions in planning a sampling program are how many sites should be sampled and how often they should be sampled. These decisions can only be made based on a knowledge of the degree of variability due to these two factors (see Section 1.6.2, Volume I). Most sampling programs require exploratory sampling so that the varia-bility with time and location can be assessed in comparison with the required uncertainty. Experience has shown that statistical approaches based on these exploratory samples usually lead to the taking of a smaller number of samples than would have otherwise been predicted. Another important consideration is that the number of samples must be consistent with the available analytical facilities.

Many times, the samples received in the laboratory may be representative of the particular conditions to be evaluated, but are not in the proper physical form for analysis. The samples may require reduction in size, drying or some form of homogenizing before subsamples can be taken for analysis. Some general considerations concerning sample preparation are discussed in Section 1.6.3, Volume I of this Manual.

The philosophy at EML is usually to collect a sufficient amount of sample so that there is not only enough to measure the constituent of interest, but also enough for reanalysis at a later time (see Section 1.6.3, Volume I). Storage of samples for later analyses requires judgment in order to avoid loss of constituents to be measured or to avoid undesirable decomposition. EML maintains an extensive library of samples associated with its research programs, in some cases going back over 30 years (Klusek, 1989).

REFERENCE

Klusek, C. S.
"The EML Soil Inventory and Archive"
U.S. Department of Energy Report EML-519 (1989)

2.7 FOOD

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2.7.1 SCOPE

The determination of the radionuclide concentration in the diet or individual food items constitutes an important element of an integrated program of radiological surveillance and assessment. An overview of EML's sampling protocols will be presented here.

2.7.2 PROTOCOLS

Food is analyzed to determine: 1) the level of contamination at the point of production, or 2) the level of intake of the contaminant for the consumer or a particular population group. Several factors must be considered in determining the sampling protocol for diet intake studies. These include the number of samples that can be handled, the effect of the lag time between production and consumption on the level of the contaminant, the importance of the relative contribution of a single food or food group, and the effect of processing of the food for consumption on the level of the contaminant. There is no single method that is entirely satisfactory for estimating human dietary intake of contaminants in foods. Several approaches will be discussed in the following section. More detailed information can be found in World Health Organization (1986).

2.7.2.1
POINT OF PRODUCTION SAMPLING

One method of food monitoring is to sample individual foods at the point of production. This is most useful for relating contaminations to local conditions of fallout, soil content, or farming practice. The geographic area to be sampled is generally relatively small. This sampling system is used, for example, by the Food and Drug Administration (FDA) in their program of food monitoring near power reactors (Stroube and Jelinek, 1985). It is very difficult however to correlate the concentration level of a contaminant in samples collected at the point of production to the dietary intake of any specific group of people.

2.7.2.2
MIXED DIET SAMPLING

Another sampling procedure often used is to duplicate the actual foods consumed by an individual during a day, a week or some specified time period ("duplicate plate" sampling). This type of sampling is used in metabolic balance studies where the intake and the retention of the contaminant are monitored on an individual basis (e.g., Spencer et al., 1973). This procedure has also been used in the U.S. Environmental Protection Agency's Institutional Diet Sampling Program (USEPA, 1974) and the California (Hospital Standard) Diet Study (USEPA, 1973). The advantage of collecting meals over a week period, and duplicating meals as consumed is that the resulting sample is a better estimate of the average dietary intake. However, since the analyses are performed on the composite of the diet, only the total intake can be estimated. Information on the contribution of the component parts of the diet is not obtained.

2.7.2.3
CONSUMPTION STATISTICS SAMPLING

A third diet sampling procedure is based on analysis of representative food items purchased locally and on food consumption statistics. The intake estimates are then calculated by multiplying the concentration estimate of each food by the respective consumption estimates per day or per year. This approach is used by EML in our ^{90}Sr in Diet Program (Klusek, 1984), Argonne's ^{137}Cs in Chicago Foods Program (Karttunen, 1982), and FDA's Total Diet Studies Program (Stroube and Jelinek, 1985).

This sampling method allows a considerable degree of flexibility for consideration of special diet types or differences in consumption by region, age, sex, income or urbanization. It is possible to reduce the number of foods or to consider more general categories of foods to reduce cost or effort in particular cases. It is recommended that the sampling take place at the retail level, however, if appropriate (i.e., rural farm intake) the sampling can take place at the consumption level.

The advantage of this method is that the analysis of a number of foods or food groups gives more information than the analysis of a single composite diet sample. It is also useful in indicating the primary sources of intake for a particular contaminant. However, the intake estimates are limited by the accuracy of the consumption statistics. A comparison of estimates of dietary intake of ^{90}Sr by mixed diet sampling and consumption estimates is presented in Kramer et al. (1973).

Food consumption statistics are available through national food sheets (e.g., FAO, 1984) or local specialists. Food consumption statistics for U.S. population groups have been published by the U.S. Department of Agriculture (USDA) in a series of surveys conducted since 1936. The "Household Food Consumption Survey" presents data on the consumption of 200 food types by income group, by region in the U.S. and by degree of urbanization (USDA, 1982). Food intake summaries for 22 sex-age categories, by racial group and by season are also available through the USDA (1983). In cases where it is necessary to compile other surveys of consumptions statistics, several reviews of the methods of measuring dietary intake are available (Block, 1982; Marr, 1971; Morgan et al., 1987).

2.7.3 EML DIET SAMPLING PROGRAM

The EML diet sampling program was developed to provide estimates of the intake of ^{90}Sr by man. These dietary intake estimates are then correlated with fallout measurements and the ^{90}Sr content of human bone. The sampling protocol or archived samples from the diet sampling program have been used by other researchers in studies of the dietary intake of other natural (Fisenne and Keller, 1970; Fisenne et al., 1987; Petrow et al., 1965; Welford and Baird, 1967) and artificial radionuclides (Bennett, 1976; Rivera, 1967) and some stable elements (Bogen, 1972; Rivera, 1962).

At EML, the diet sampling is grouped into 19 food categories representing the five basic food groups. On a quarterly basis, 42 food items are purchased in New York City markets. The foods purchased within each category approximate the distribution of food consumption within that category. The food items sampled are shown in Table 2.8. The quantities purchased for an individual item allow for duplicate ^{90}Sr analyses and sufficient archival material. Additional information on % ash of certain foods and the amount of wet sample needed for a 10 g sample of ash is discussed in Procedure Sr-02-RC, Section 4 of this volume. It is recommended that the purchases be made in several chain supermarkets or that a variety of brands of packaged goods be purchased.

Three categories of food intake are not sampled: fats and oils, sugars and sweets, and beverages. The total liquid intake estimate and the concentration in water can be used to obtain an estimate of the intake from the beverage category. Omission of these categories is valid for most radionuclides and for metallic contaminants. Studies of tritium intake or pesticides would probably require their inclusion.

Milk is a particularly important diet component and often a prime contributor to ^{90}Sr intake. Since it is easily sampled, we routinely obtain daily samples of pasteurized milk which are then composited and analyzed monthly.

The foods are prepared as for consumption (but are not cooked). Using consumption estimates from the USDA for all urbanizations (central city, suburban, and non-metropolitan) of the U.S. (USDA, 1982), the daily intake of each food category is calculated from the nuclide concentration multiplied by the daily consumption values. The total intake is calculated from the total of all food categories. Quarterly sampling of diet items has been sufficient to demonstrate seasonal variations and to provide satisfactory average yearly intake estimates for typical Northern Hemisphere population regions.

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TABLE 2.8
EML DIET SAMPLING PROGRAM FOOD PURCHASE LIST

Food group	Food category	Food item purchased[1]
Dairy products	Milk	Whole milk
Vegetables	Fresh vegetables	Lettuce, cabbage, spinach, peas, beans, tomatoes
	Canned vegetables	Peas, beans, tomatoes
	Root vegetables	Onions, carrots, turnips
	Potatoes	White potatoes
	Dry beans	Navy beans
Fruit	Fresh fruit	Oranges, apples, bananas, melons, berries
	Canned fruit	Peaches, pears, pineapple, applesauce
	Fruit juice	Orange, pineapple, tomato, grapefruit
Grain products	Bakery products	White bread
	Flour	White flour
	Whole grain products	Whole wheat bread
	Macaroni	Spaghetti, elbow macaroni
	Rice	White rice
Meat, eggs, and fish	Meat	Pork, beef
	Poultry	Chicken legs, chicken breasts
	Eggs	Fresh white eggs
	Fresh fish	Halibut, fillet
	Shell fish	Shrimp, clams or oysters

[1] *The amount of item is dependent on the food consumption in the district being studied. See text.*